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NATURAL HISTORY MUSEUM OF
LOS ANGELES COUNTY

A NEW EXHIBIT

Microbes: Invisible Invaders, Amazing Allies

MICROBES AND THE SECRET OF LIFE

THE PHYSICIAN AND ESSAYIST Lewis Thomas described Oswald Avery as a "small, vanishingly thin man with a constantly startled expression and a very large and agile brain." As if caressing that brain, Avery was wont to stroke his bald head when thinking deeply, which is what he did much of the time, and often about the bacterium that causes pneumonia. Avery spent the bulk of his career, from 1913 to 1948, investigating the workings of this one organism, the pneumococcus, a preoccupation he called "digging a deep hole in one place." The hole he dug was so deep that it descended beyond pneumonia to encompass the mystery of how life perpetuates itself.

How life perpetuates itself—it may seem odd to encounter the phrase in the context of microbes. While one-celled organisms such as bacteria are certainly alive, viruses, little more than tough shells of protein much too tiny to be cells, may not properly be alive at all. Yet by the middle of the century it had become clear that, alive or no, viruses had in common with cells a number of the basic processes necessary to perpetuate life. Indeed, viruses even usurped some of those cellular processes for their own purposes. The secrets of cells were in part the secrets of viruses; they shared a common inspiriting spark. To learn about one was to discover the other.

IT WAS AVERY who provided a major insight toward the realization of all this and more, but such a scope was hardly his intent. He might have been content to labor away in his small, spare laboratory at New York's Rockefeller Institute, forever investigating the intricacies of pneumonia bacteria, had it not been for a puzzling experiment conducted in England in 1928 by a physician named Frederick Griffith. Griffith had learned that the pneumococcus that caused lobar pneumonia, the most lethal type of the disease, came in two forms, smooth and rough (S and R, for short). The S-form was the deadly type. Its glossy, gelatinlike covering protected it from the body's immune system. Not so the R-form. The result of a mutation, the R-form was unable to produce a smooth, protective surface and thus was easily dealt with by the body's immune defenses. It was harmless.

In order to learn more about these dissimilar bacterial siblings, Griffith injected mice with a dose of the harmless rough form and a dose of the lethal smooth form that he had killed beforehand by exposing it to heat, thereby rendering the bacteria harmless. He expected, therefore, that the mice would continue to scurry around unharmed, as before.

Griffith was in for a shock. Not only did many of the mice stop scurrying, they died—of pneumonia. And when Griffith examined the dead mice, he found their blood swarming with living, virulent S-form pneumococci.

Where could the live, lethal bacteria have come from? As far as Griffith was concerned, there was only one answer: he had botched the experiment by inadvertently injecting live S-form bacteria into the mice. That had to be the explanation, for virulent microorganisms couldn't appear from nowhere. But when he tested his rationale by injecting only the heated S-form into a fresh batch of mice, without first injecting the R-form, nothing happened. The heated bacteria didn't affect the mice; the pneumococci must have been dead after all.

Puzzled, Griffith performed his original experiment once more, inoculating another bunch of mice with the live rough bacteria and the heated smooth form—which he knew to be dead and harmless—and waited to see what happened. He didn't have to wait long. Soon mice started dropping as before. Something was going on within these mice to allow dead bacteria to transform live, harmless bacteria into a virulent form. And not only were these particular bacteria transformed, but the change was permanent and inheritable from generation to generation. Those newly created S-form bacteria gave rise to more S-form bacteria, which themselves produced yet more S-form bacteria. Whatever had happened within those mice had altered the bacteria forever.

WHEN GRIFFITH PUBLISHED his results, however, people were incredulous. Life simply wasn't like that. Things didn't turn into other things for no apparent reason—things didn't turn into other things, period. And no one was more skeptical than Oswald Avery. Such apparent craziness had no place in Avery's meticulous, thoughtful scientific life. But when a year later the experiment was repeated by others, and when two years after that Avery's own associates found that they could obtain the same results without mice—that is, just combining live R-form and heat-killed S-form pneumococci in a glass dish was enough to produce brand-new live and virulent S-form bacteria—Avery could no longer ignore the matter.

Then, several months later, another Rockefeller microbiologist performed an experiment that engaged Avery for good (in fact, he was working in Avery's own lab). J. L. Alloway grew a culture of S-form bacteria and crushed it, setting free the contents of the bacteria. He then

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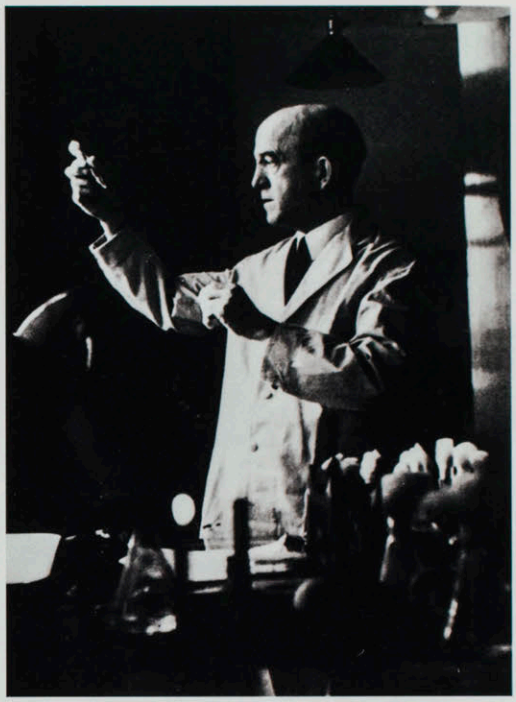
COVER: The spore mother cells, or asci, of the fungus *Ascobolus* are spilling out of its yellow fruitbody; each ascus contains eight spores, and each of these is capable of establishing a new colony for the fungus. Caps at the tips of the asci fly open, and the tiny spores are shot into the air, to be dispersed great distances by even the gentlest of winds. Spores become purple as they mature, and the darkest will be shot off next. The entire fruitbody is about a millimeter tall. Photograph by George Barron.

***Ascobolus* species live out their life cycle on the dung of herbivores, a rich source of nutrients for fungi and other microscopic organisms. The exciting world of microscopic life is the subject of a new exhibition opening at the Museum of Natural History in late May (see page 10).**



Rockefeller University Archives

Oswald T. Avery, ca. 1930

added the resulting filtrate, which contained no whole bacterial cells at all, to a culture of the R-form. The result: transformation once again. A new generation of virulent S-form began to grow. Not only were mice not necessary to effect the change, but whole bacteria themselves were not necessary. All that was needed was extract from the bacterial innards. When Alloway added alcohol to this extract, he produced a "thick, syrupy precipitate." People in the lab began calling it the "transforming principle."

Now Avery was engaged indeed. Alloway's thick syrup worked, yes, but it contained all sorts of impurities, so many that it was impossible to know just what in the viscous liquid actually caused the transformation. Avery decided to find out. Usually given to erudite monologues, his characteristic cry now became, "What is the substance responsible?" It took him over 10 years to find out.

Enlisting the help of colleagues Colin MacLeod and Maclyn McCarty, he grew the virulent S-form bacteria in twenty-gallon vats of nutrient solution, and then, in a series of laborious steps, painstakingly removed everything that was not the transforming principle. He used a centrifuge to whip away extraneous materials, filters to sift them away, various chemicals to eat them away. The last step involved gently stirring alcohol into the purified liquid that remained. Soon, before the eyes of the astonished technicians, cobwebs of whitish, translucent threads appeared and began to cling to the stirring rod. From the twenty gallons they had started with, Avery and his colleagues had produced just under a hundredth of an ounce of this stringy material. It was DNA.

When Avery published his findings in 1944 (at the age of sixty-seven, "the ever rarer instance of an old man making a great scientific discovery," as a colleague put it), DNA, or deoxyribonucleic acid, was known as a substance that inhabited the nuclei of cells and viruses alike, but what it was doing there wasn't clear. In fact, many considered DNA to have no function whatsoever other than that of providing a protective coating for the real stuff of genes, protein. DNA was a small molecule made up of just four subunits. It was boring, monotonous stuff, as interesting as a layer of mortar between bricks. Protein, on the other hand—complex, versatile protein—excited people. It was protein that most likely made possible the flow of genetic inheritance from one generation to another, that probably constituted the transforming principle.

But now, here was prudent, careful Oswald Avery suggesting that no, it wasn't protein at all. DNA wasn't simply a structural component—it might actually be the transforming principle itself. He was too cautious to say so in his published paper, but in a letter to his brother he revealed his excitement.

> If we are right, & of course that's not yet proven, then it means that nucleic acids are *not* merely structurally important but functionally active substances in determining the biochemical activities and specific characteristics of cells—& that by means of a known chemical substance it is possible to induce *predictable* and *hereditary* changes in cells. This is something that has long been the dream of geneticists. . . . Sounds like a virus—may be a gene.

May be a gene, indeed. Today it's common knowledge that it is indeed DNA that contains the genetic instructions in the heart of every cell, and it is DNA, or its fellow nucleic acid, RNA, that occupies the heart of every virus as well. Avery, however, never did receive appropriate recognition for what he had accomplished. When he died in 1955, late enough to have witnessed James Watson and Francis Crick's elucidation of the molecular structure of DNA, he was still primarily known, if at all, as the shy and quiet "Professor" who studied pneumonia. The plaudits and honors, the celebrity and notoriety, devolved elsewhere, on those who followed and expanded upon his lead. "He was a quiet man," observed one of his colleagues, "and it would have honored the world more, had it honored him more."

Peter Radetsky

Peter Radetsky teaches in the Science Communication Program at the University of California, Santa Cruz. He is a contributing editor for Discover *magazine and was content developer for the exhibit* Microbes: Invisible Invaders, Amazing Allies, *on view at the Museum of Natural History in Exposition Park from late May through summer. His most recent book is entitled* Allergic to the Twentieth Century: The Explosion in Environmental Allergies—from Sick Buildings to Multiple Chemical Sensitivity *(Little, Brown, 1997).*

This article was adapted from Dr. Radetsky's book, The Invisible Invaders: Viruses and the Scientists Who Pursue Them *(Back Bay Books, Little, Brown, 1991) and is reprinted with the permission of the publisher. The book is available in the Exposition Park museum's Explore and Gallery Stores.*

On Sunday, August 23, in a lecture and book signing at the Museum of Natural History, Dr. Radetsky will give a fascinating look at science in progress as he describes the latest progress in the search for treatments, preventions, and cures for diseases caused by microbes. For more information on this program, please call the museum's Education Division at 213/763-3534.

DIETARY SUPPLEMENTS FOR FUNGI

"Although their importance in the ecosystem is almost always underrated, fungi drive our planet's carbon cycle," asserts George Barron, a Canadian biologist.

In a typical acre of forest, the soil teems with organisms at work decomposing dead trees and other plant litter and in the process releasing nutrients so that they are available to support new growth. Certain "saprophytic" fungi are the principle decomposers of plant remains, particularly woody debris (cellulose and lignified cellulose).

Other fungi, the "mycorrhizae," also have a presence in the soil. Each tree has tens of thousands of miles of microscopic fungal threads, or hyphae, associated with its roots, and it is this mycorrhizal network that supplies the tree with all the water and nutrients essential to its growth. In turn, the fungi receive sugars that the tree manufactures through photosynthesis in its leaves.

Fungi are thus directly involved in both the buildup of carbohydrate, through the mycorrhizae, and the breakdown of carbohydrate, through the fungal saprophytes' decay of plant debris. It is not surprising then that, excluding the roots of the higher plants themselves, fungi are the dominant organisms in the forest soil, making up about 90 percent of the biomass, or collective weight of living stuff. Bacteria, protozoa, nematodes, ciliates, flagellates, insects and their larvae, and all the organisms we tend to think of as most important in soil together contribute only 10 percent of its living protoplasm.

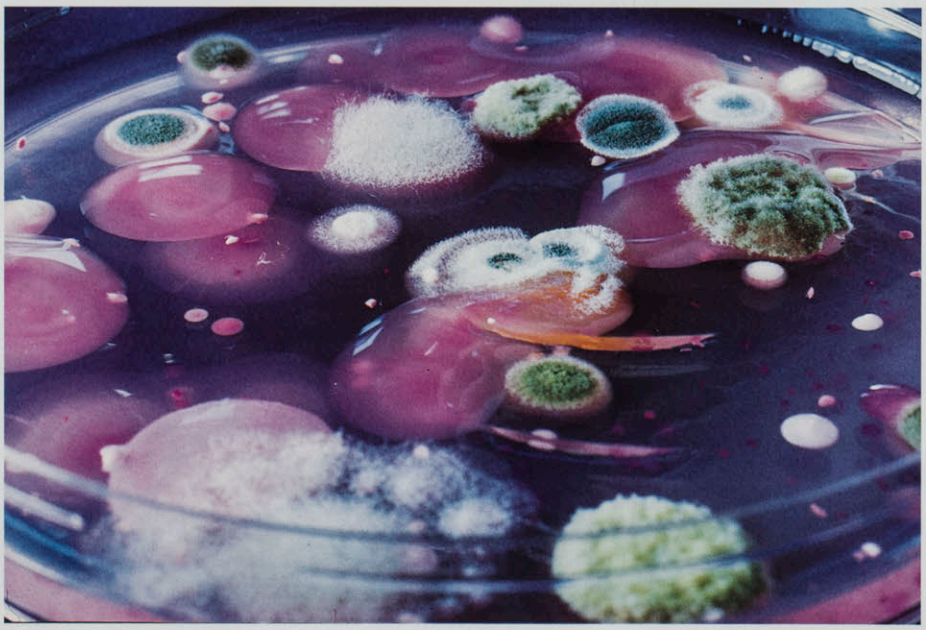
Fungi and their relatives are Dr. Barron's specialty. With colleagues in the Department of Environmental Biology at the University of Guelph in Ontario, he has studied a number of cellulose- and wood-decaying fungi; he is particularly interested in species that have adopted, as a sideline, a predatory way of life.

For more than a hundred years, botanists have known that certain fungi are able to trap and consume nematodes, the tiny nonsegmented worms that are present in great numbers in all soils. More recently it has been found that many species of saprophytic wood-rotting and cellulose-degrading fungi are also, on occasion, predatory, attacking and digesting nematodes and other microorganisms such as copepods, rotifers, bacteria, and springtails.

These aggressive fungal hunters employ an array of novel devices—including chemical lures, sticky knobs, adhesive nets, constricting rings, and paralyzing secretions—to capture or inactivate their prey. The victims are then consumed while still alive, perhaps so as not to attract competition from microscopic carrion feeders.

Venus flytraps and sundews, which trap and devour insects as nitrogen supplements, are able to flourish in low-nitrogen environments such as bogs. Botanists believe that the carnivorous fungi attack their tiny victims for the same reason: they are supplementing their diets with nitrogen and other nutrients to balance their high carbon intake from a regular regimen of the cellulose in plant debris.

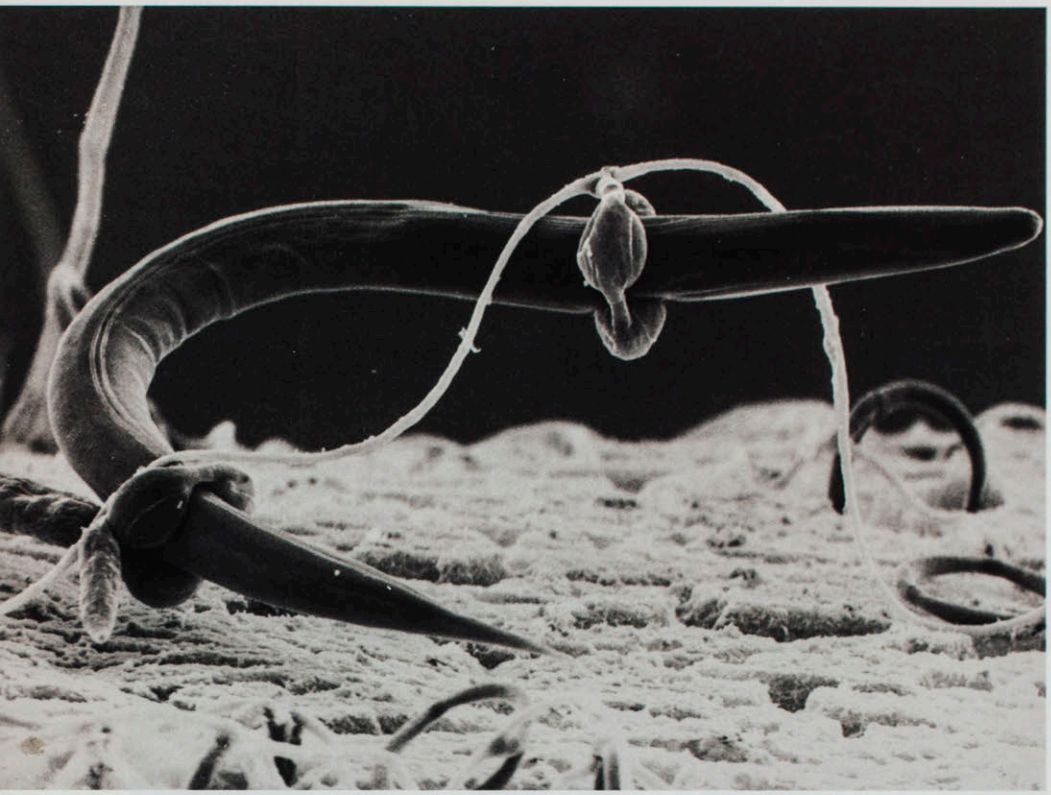
The scenes shown here, from the files of Dr. Barron and his associates, were played out on culture media in laboratory dishes. In similar experiments with a variety of fungi and microscopic host organisms, some fungal predators have shown preference for certain species of victim, while others are omnivorous and voraciously attack any likely organism in their vicinity. The full richness and variety of the interactions amongst soil organisms will only be revealed by further observations, not only in the laboratory but more importantly in the field—in the much more complex arena of Nature itself.



George Barron

When a tiny crumb of soil (1/1,000 of a gram) is spread out on nutrient agar in a Petri dish, the organisms present can grow and reproduce without the constraints inherent in the soil itself. The dish is soon overrun with thriving populations of yeasts (the smallest pink, red, and white circular forms), bacteria (the large, translucent pinkish globular masses), and various types of filamentous fungi (the fuzzy green and white colonies).

Microbes of these kinds, mushroom-type fungi, worms, insects, and other organisms work together to degrade plant debris, both in the soil and on the soil surface. In this process 85 billion tons of carbon is returned to the atmosphere each year. The fungi, which have by far the largest biomass in forest soils, carry out the bulk of this crucial recycling.



SEM George Barron

Species of *Arthrobotrys* are active cellulose-degrading fungi, but they have another more sinister side. Here, the fungus *Arthrobotrys anchonia* has used a chemical lure to persuade a soil-inhabiting nematode to enter one of the upright rings, each composed of three cells, that the fungus has generated from its filamentous threads. When the eelworm's body wall touches the inner surface of the ring, the three cells explode inward, pinching and securing the victim. In desperate but futile attempts to escape, a nematode will often stick its tail in another ring (as in this case) and become completely immobilized.

Nematodes are muscular little animals, and occasionally one is able to break a ring off at the stalk and swim away. The ring cells, however, are still capable of attack. They germinate and penetrate the wall of the victim; then assimilative filaments are sent lengthwise into the body cavity. The contents of the host are digested within 12 hours, and the nutrients are siphoned off, to be used for additional growth and reproduction.

RIGHT: Here, the trap was sprung, but the nematode has escaped. Although the constricting ring's action is very quick, there is usually a pause of a few seconds between the nematode's entering the ring and the beginning of closure. This lag time lets some nematodes wriggle further into the ring before capture, but it can also be a window of escape for other potential victims.

SEM Nancy Allin and George Barron

SEM George Barron

The cellulose-degrading fungus *Arthrobotrys oligospora* has captured and invaded a nematode; the now-collapsing corpse is held fast by the fungus's complex and multibranched net system. The fungus has grown directly through the cuticle of the host, and its body's contents are being digested by enzymes produced by the fungus's assimilative hyphae, which will soon fill the worm.

The net traps created by this fungus are thoroughly coated with a biological "super glue." An unwary nematode, stopping perhaps to graze on bacteria, touches the net and finds itself caught and held by an unbreakable chemical bond. The violence of its efforts to escape, as well as exhausting the victim, only result in contact with other parts of the sticky trap or with other traps.

A MEAT-EATING BULL OF A DINOSAUR

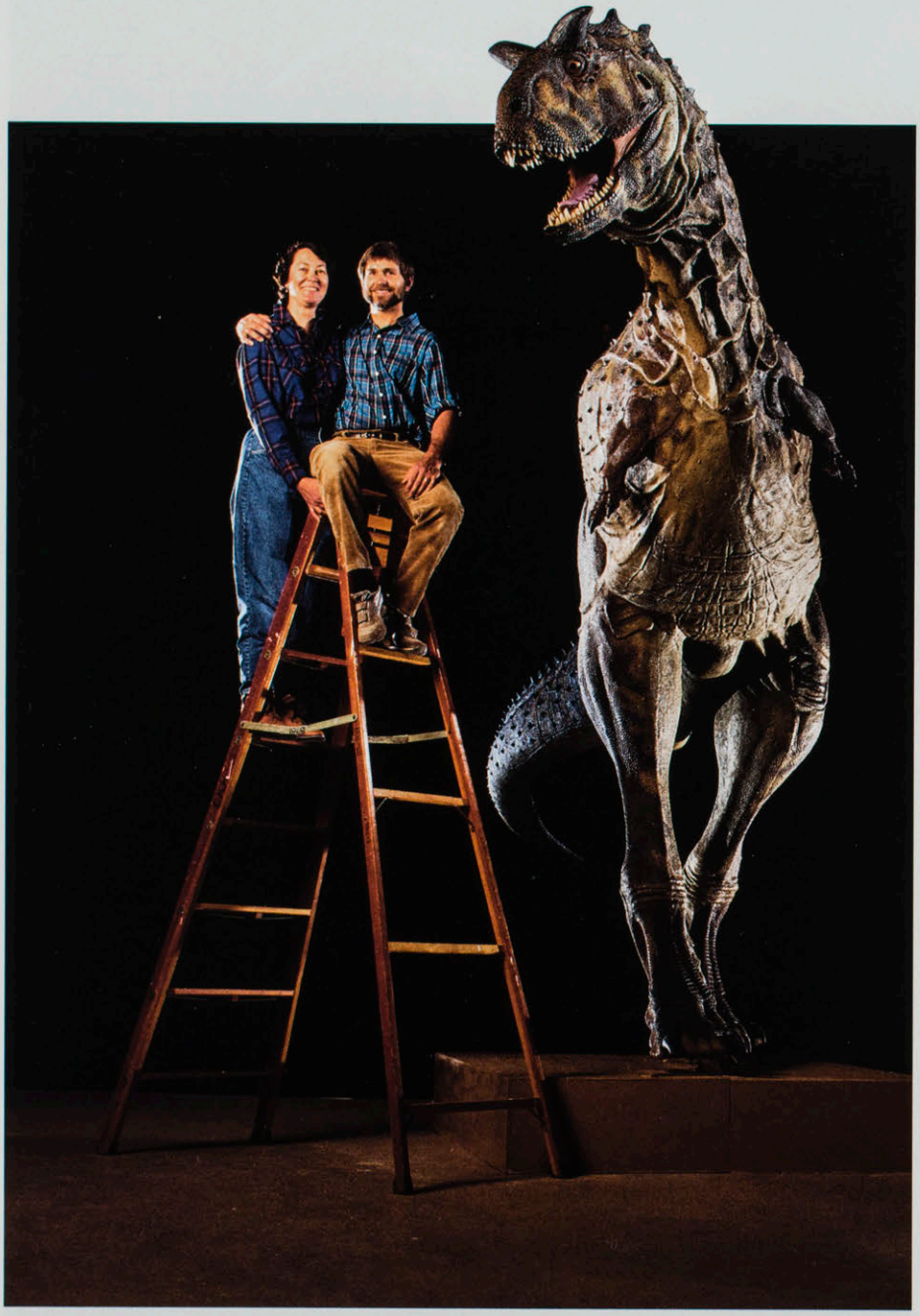
OCCASIONALLY EXCAVATORS will find a fossilized impression of skin along with the skeleton of a dinosaur, and the skin imprint can help round out a picture of how the animal might have looked when alive. But until the remains of *Carnotaurus sastrei* were discovered in 1984, on a remote ranch in northern Patagonia, Argentina, all the dinosaur skin impressions that had been found were of plant-eaters. The paleontologists excavating the *Carnotaurus* skin were surprised to find that this carnivore had been studded with cone-shaped protuberances along its upper body.

In the Exposition Park museum's first floor dinosaur exhibits, the visitor can see two views of *Carnotaurus sastrei.* A cast of the skeleton is mounted in a running posture, with its remarkably abbreviated forelimbs held close to its body and its tail lifted high. The original skeleton was collected by Jose F. Bonaparte of the Museo Argentino de Ciencias Naturales in Buenos Aires; Dr. Bonaparte named the species (*Carnotaurus,* or "meat-eating bull," refers to its predatory nature and the horns on its forehead) and gave the complete description of it for science in our museum's serial publication, Contributions in Science.

Near the 30-foot-long skeletal mount is a full-sized sculptural restoration of the dinosaur as it might have looked in life. The sculpture and the mounting of the skeleton, which were commissioned from artists Stephen and Sylvia Czerkas, are the products of 7 years of research, design, and fabrication. In creating the sculpture, the first of its kind in the world, the artists were pleased to have not just the bones but also the skin impression to work from. Dr. Bonaparte has expressed his admiration for their efforts and believes that they have produced an exceptionally good likeness of this long-extinct beast.

In our current exhibit of *Carnotaurus sastrei,* the skeleton casts eerie shadows on the walls while the model looms out over museum visitors, giving a dramatic sense of the scale of life in the Age of Dinosaurs.

Be sure to see *Dinosaurs,* a special exhibition of life-size animated sculptures and real fossil bones, before it closes at the Museum of Natural History in Exposition Park in mid-May. For more information, please call 213/763-DINO.



Stephen and Sylvia Czerkas with their sculpture of *Carnotaurus sastrei.* The husband and wife are founders and directors of The Dinosaur Museum in Blanding, Utah, and have organized and toured several international exhibitions on dinosaurs and prehistoric life. Their sculptures are on view in many of the world's museums: our institution has a life-sized *Allosaurus* as well as the *Carnotaurus.* Photograph by Louie Psihoyos; used with permission.

HILDEGARDE HOWARD, 1901–1998

Hildegarde Howard Wylde, Chief Curator Emerita of Science at the Natural History Museum, died at her home in Laguna Hills on February 28, 1998; she was 96. An internationally recognized scholar of fossil birds, Dr. Howard was one of the museum's most distinguished scientists.

Dr. Howard began her association with the museum in 1921, when, as a student at UCLA, she obtained a part-time position sorting materials from the then recent excavations from the Rancho La Brea deposits. She continued this work throughout her student years, but it was the fossil birds of that famous site that quickly drew her attention and led to her specialization in avian paleontology. She met her future husband, Henry Anson Wylde (who was Chief of Exhibits at the museum at the time he retired) when they both were assigned to sorting fossil bones from Rancho La Brea in the basement of the Exposition Park museum; they were married in 1930.

At the University of California, Berkeley, Dr. Howard obtained her B.A. (1924), M.A. (1926), and Ph.D. (1928) degrees. In 1929, she accepted a full-time, permanent position at the museum; although her title was at first Junior Clerk and soon Junior Assistant in Vertebrate Paleontology, she was actually charged with the care of the fossils from Rancho La Brea and with research on the birds of this collection; this fact was finally recognized with her promotion to Curator in 1938. She was probably the first museum scientist to hold a curatorship with a specialty as an avian paleontologist.

After she was appointed Chief Curator of Science in 1951, she was responsible for an important expansion of the museum's scientific staff. She retired 10 years later but continued to come into the museum to carry out her research for decades thereafter. She published her last scientific paper, one of over 150 publications, in 1992.

Dr. Howard published on fossil birds from all over the world, and late in her career, when construction in southern California boomed, did a number of studies of fossil birds from the marine rock formations of the region. But her most accomplished works were her monographic studies of the birds from Rancho La Brea. Her research on these fossils was important not just to science but to exhibitry as well. After sorting through and identifying thousands of disarticulated bird bones recovered from the tar pits, she oversaw the preparation of the museum's first skeletal mounts of the extinct birds of Rancho La Brea; many of these dramatically posed skeletons are currently on exhibit in the George C. Page Museum.

Hildegarde Howard, 1961. Photograph Library, Natural History Museum of Los Angeles County.

Among the awards that Dr. Howard received during her exceptional career were honorary memberships in several scientific societies. In 1953, she was presented with the distinguished Brewster Medal of the American Ornithologists' Union. After retirement, she received a Guggenheim Fellowship in support of her continued research in paleornithology. Her long dedication and service to the Natural History Museum were recognized in 1977, when the Hildegarde Howard Hall of Cenozoic Life was dedicated in the Exposition Park museum.

HEARST FOUNDATION ENDOWS EDUCATION PROGRAMS

The William Randolph Hearst Foundation has contributed $200,000 to the Hearst Education Endowment, a long-term investment that helps provide annual support for the museum's educational programming.

The endowment, which has grown steadily since its creation in 1989, has helped sustain numerous educational initiatives, including professional training workshops for southern California educators, school tours, docent training, and special programs for adults, senior citizens, disabled children, and at-risk youth.

Each year, the museum's Education Division serves more than 210,000 children, adults, and science educators, providing a variety of programs that complement and strengthen elementary and secondary education and social studies curricula, at a cost of over $1.2 million. In presenting the gift, Thomas Eastham, the Hearst Foundation's vice president and western director, said, "Our directors regard this grant as a further endorsement of the museum's fine programs, its progress, and its newly stated mission of enabling all people 'to understand and appreciate their natural and cultural heritage'."

"We are deeply grateful to the Hearst Foundation for their continuing support of our educational programs," said Dr. James L. Powell, president and director of the museum. "The foundation has been among the leaders in understanding and supporting the vital role that museums like ours play in the effort to reform science education. That effort is far from finished, how-

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FOSSIL FLIES IN AMBER

FOR AN ENTOMOLOGIST, AMBER IS a window into the past. Inside the hardened, fossilized tree resin, insects are frequently preserved in stunning detail, and sometimes in all the various stages of their life cycles. These ancient specimens can not only reveal the life histories of long-dead species but give us clues to when our modern fauna first appeared and when distinctive features of today's insect lineages first evolved.

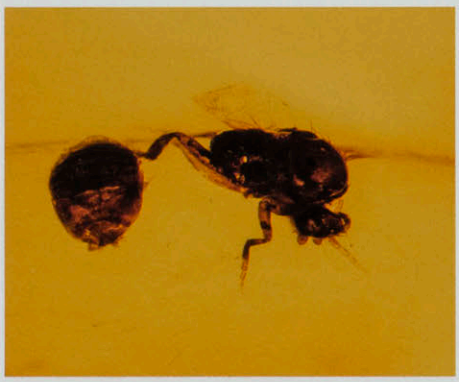
The Entomology Section of the Natural History Museum recently obtained a collection of 122 pieces of amber, from the Yantarni mine in Kaliningrad, at the south end of Russia's Baltic Sea coast. This amber is approximately 35 to 40 million years old and thus was formed around the end of the Eocene epoch and the beginning of the Oligocene. Although the insects it contains lived long after the Age of Dinosaurs, which ended 65 million years ago, the Baltic amber period was still a time when life forms looked very different than they do today.

The amber itself was produced as a secretion of trees, but the actual tree species are still being debated. Scientists have traditionally believed the source of Baltic amber to be a pine because the amber contains many pinelike fossils, including wood, needles, and cones. But analysis of its spectral qualities has revealed that this amber closely resembles resins produced by more primitive conifers related to the monkey puzzle tree and others of the genus *Araucaria*. Like the ginkgos and the palmlike cycads, which lived in Europe during the Baltic amber period but now have a much more reduced distribution, *Araucaria* trees today are native only to the Southern Hemisphere.

Our new amber collection is interesting to me because each piece contains one or more phorids, the tiny flies that I study. Members of this family, which is found worldwide, have a wide range of life styles, from scavenging, predation, and parasitism to plant eating. Their abundant populations and small size—the largest phorids are just under a quarter of an inch long—guaranteed that many would be caught in the sticky resin flowing from amber-producing trees.

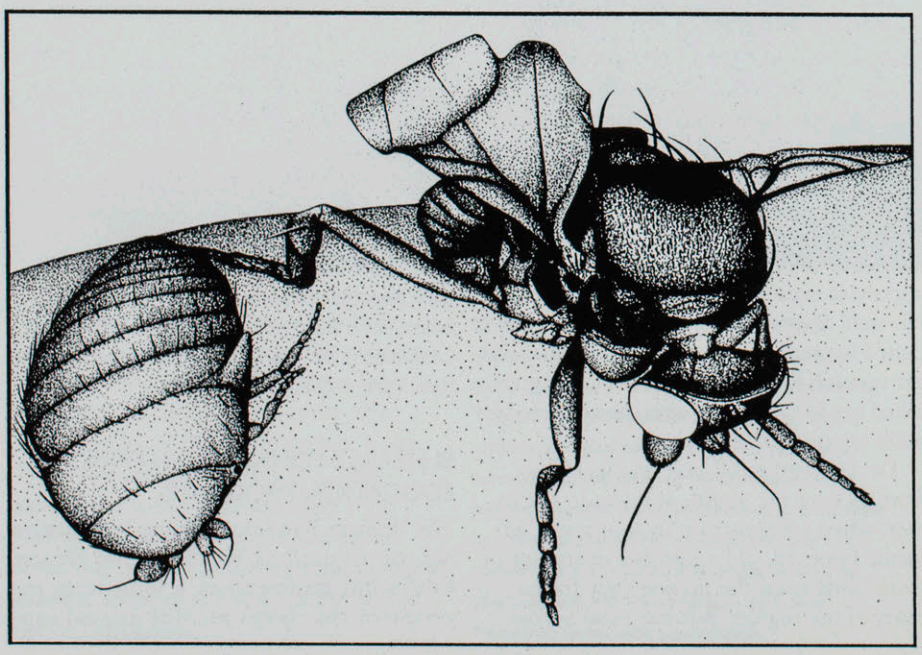
The Baltic amber period was one of the most interesting times in phorid evolution. Unlike older Cretaceous amber, where most of the phorids present are barely recognizable as such, the Baltic amber contains modern groups along with their relatively primitive ancestors. There are some surprises as well, including the earliest known specimens of a truly bizarre group of phorids (the subfamily Aenigmatiinae) in which the females look something like cockroaches; one couple was in the act of mating when captured by the amber resin (see illustrations below). The early relatives of other modern phorids with cockroachlike (or "limuloid") females are also present in the Baltic amber. But the fossilized females have well-developed wings, while their closest living relatives are wingless. Today's limuloid phorids live in the nests of ants or termites, potential hosts whose fossils are common in Baltic amber.

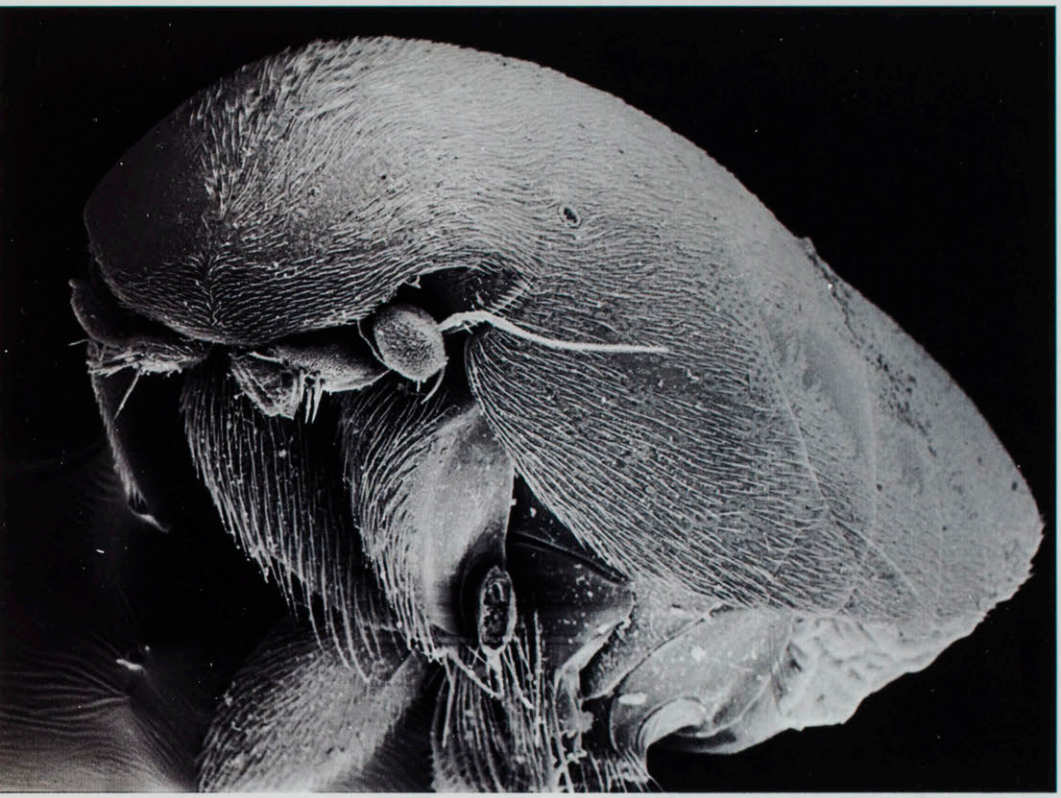
Other better known phorids are pre-



A pair of phorid flies from the Eocene (approximately 40 million years ago) preserved in Baltic amber; the drawing, by Jesse Cantley, is based on the photo he took, at left.

Apparently these small insects—the male is about 2 millimeters long—were flying as a mating pair and, when they landed on the sticky resin, tried to scamble away from each other. The female, at left, has a distinctive cockroach-like appearance, with small eyes, reduced wings, and a rounded "limuloid" body. These flies are being described as a new genus and species by Dr. Brown.





A modern limuloid female phorid fly (genus *Epicnemis*), from Thailand. Note the smooth, founded body form, reduced eyes, and complete lack of wings (males of this genus have normal-sized eyes and well-developed wings). Scanning electron micrograph by Brian V. Brown.

served in the new collection. There are several specimens of *Anevrina*, a genus whose species feed on carrion in the burrows of mammals. There are a number of *Triphleba* phorids, whose larvae are known to feed on buried plant and animal material. Finally, there is a species of *Godavaria*, a genus now found only in the Himalayan region of southeast Asia, thousands of miles from the Baltic Sea.

In the new collection, there is at least one genus of phorids new to science as well as many undescribed species. These novelties are not surprising, because most species of insects are not expected to survive unchanged for more than a few million years. Describing these new forms from specimens in amber is always a challenge, as the crucial structures that need to be examined often seem to be just out of sight, or hidden by a pair of inconveniently bent legs. Patience on the entomologist's part, as well as an abundance of specimens upon which to base descriptions, is the key to increasing our knowledge of these fossils from the dim past.

Brian V. Brown
Assistant Curator of Entomology

As head of the Natural History Museum's Entomology Section, Dr. Brown has responsibility for a collection of more than 5 million specimens of insects, including one of the world's largest collections of phorids. His research focuses on modern "ant-decapitating" phorids, a group whose members show promise as biological agents for controlling fire ants and other pest species.

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PROGRAMS FOR MEMBERS AND VISITORS

Lecture and book signing

■ NIGHT COMES TO THE CRETACEOUS

Dinosaur Extinction and the Transformation of Modern Geology

Sunday, June 7, 2 p.m., Jean Delacour Auditorium, Museum of Natural History

What killed the dinosaurs? For many years, this question has been the greatest unsolved mystery in science. Then in 1980, a radical theory was proposed: 65 million years ago, an asteroid or comet as big as Mt. Everest, traveling at 100,000 miles per hour, struck the earth, throwing up a dust cloud that darkened the sky, caused the temperature to plummet, and killed the dinosaurs and 70 percent of all other species. James L. Powell's new book, *Night Comes to the Cretaceous* (W. H. Freeman, May 1998), is the first comprehensive and objective account of the ways in which this incredible theory changed the course of science. In his illustrated talk, Dr. Powell, who is President and Director of the Natural History Museum, tells the dramatic story of how Nobel-prize-winning physicist Luis Alvarez and his son Walter stumbled onto evidence suggesting that a single random event caused the extinction of the dinosaurs—a claim that many scientists found unbelievable. Years of bitter debate and intense research culminated in an astonishing discovery: an immense impact crater buried deep in the Yucatán Peninsula in Mexico was identified as Ground Zero. The unbelievable appeared to be true. $7 members, $9 nonmembers, $5 students with I.D.

Lecture

■ ANCIENT DNA AND MICROORGANISMS IN AMBER

Sunday, June 28, 2 p.m., Jean Delacour Auditorium, Museum of Natural History

Amazing things are found in amber! Dr. Raul J. Cano, professor of microbiology and director of the Environmental Biotechnology Institute at California Polytechnic State University, discusses his techniques for recovering (and sometimes culturing) amber-entombed microorganisms—yeasts, bacteria, fungi, and even DNA from viruses. Dr. Cano will describe the relevance of his work to the archaeology of infectious maladies and to our understanding of the evolution of new and emerging diseases. $7 members, $9 nonmembers, $5 students with I.D.

Around us, on us, and in us—invisible to the naked eye—is a universe of microbes. Here, life spans are measured not in years or days but in hours and minutes. A life history may involve more than a dozen stages and some rather astounding transformations. Individuals are often exotic in appearance, and populations are unfathomably large: the total number of bacteria in your mouth, for example, is greater than the number of people who have ever lived.

The hidden world of microbes is the focus of a new interactive exhibition at the Museum of Natural History. *Microbes: Invisible Invaders, Amazing Allies*, opening at the end of May and on view through summer, takes visitors on a journey into the tiny landscapes and watery habitats of microscopic life forms. Through interactive displays featuring virtual reality, three-dimensional animation, and special effects, families are introduced to various bacteria, viruses, microscopic fungi, and protozoa—including some notorious species that have earned the labels "germs" and "pathogens."

***Microbes: Invisible Invaders, Amazing Allies*, is a national traveling exhibition sponsored by Pfizer, Inc., in collaboration with the National Institutes of Health.**

■ WILLIAM S. HART BIRTHDAY CLUB

Saturday, June 13, 6:30 p.m., William S. Hart Park, Newhall

The Friends of Hart Park and Museum invite you to join the Bill Hart Birthday Club. Membership includes two invitations to two very special events at Hart Park and Museum. The first is a "To Die For" murder mystery dinner at the mansion, to be held this year on Saturday, June 13. A second event is planned for December. Bill Hart would have been 134 years old this year, so membership in the club is $134 per couple and includes both the June and December events. For more information, please call 805/254-4584.

ADULT FIELD TRIPS

■ THE HIDDEN PAST

Sunday, May 31, 10 a.m. to 4 p.m.

See a different side of Los Angeles history on our tour of historic cemeteries. You'll find that the mysterious, the mystical, the precious, and the outlandish all coexist among the tombstones, which say as much about the living as they do about the dead. We will visit the graves of some of Los Angeles's most famous and infamous residents with archaeologist and historian Dr. Paul Bahn. We'll "depart" from Hancock Park in air-conditioned motor coach; pack a lunch and join us for a lively outing. $40 members, $50 nonmembers.

■ SHARK DIVE

Saturday, May 30, 6:30 a.m. to 5 p.m. Children ages 8 and older welcome if accompanied by an adult

Join us on a breathtaking voyage into the mysterious realm of the blue shark. We will safely enter the water in the protected setting of a specially designed snorkeling cage to observe blue sharks in their natural environment off the coast of Catalina Island. Participants may even have the opportunity to assist researchers from the Southern California Marine Institute in their ongoing program of tagging juvenile blue sharks. Marine biologists from the Hydrosphere team and museum instructors will round out our day with presentations and workshops on shark behavior and natural history and on oceanography and navigation.

Masks and snorkels, children's wetsuits, breakfast, lunch and two snacks are included; adults will need to provide their own wetsuits. Early reservations are needed for this very popular trip. $100 members, $110 nonmembers.

■ A DAY IN WINE COUNTRY SOUTH

Saturday, July 18, 8:30 a.m. to 4 p.m. Adults age 21 and older

On this excursion to southern California's own wine country, we'll take a tour of the Calloway and Thornton wineries in Temecula and sample the wares. As we enjoy a gourmet picnic lunch beneath a grape arbor, we will learn what makes this area of the state so great for vineyards. Travel is by air-conditioned motorcoach; tour, wine-tasting, and lunch are included. $65 members, $75 nonmembers.

FAMILY PROGRAMS

■ STUCK ALL NIGHT AT THE TAR PITS

Overnight, Saturday, May 9, to Sunday, May 10, 7 p.m. to 8 a.m. Page Museum. Children ages 5 and older with accompanying adult

Come and spend an exciting night of gooey activities at the Tar Pits. Take a flashlight tour of the museum, cast a few fossils to take home, and meet some real wild animals! We will also create a special gift for Mother's Day. An evening snack and a light breakfast are included. Participants must bring their own sleeping bags and air mattresses. $40 members, $50 nonmembers.

■ BIG REPTILES, BIG TEETH!!!

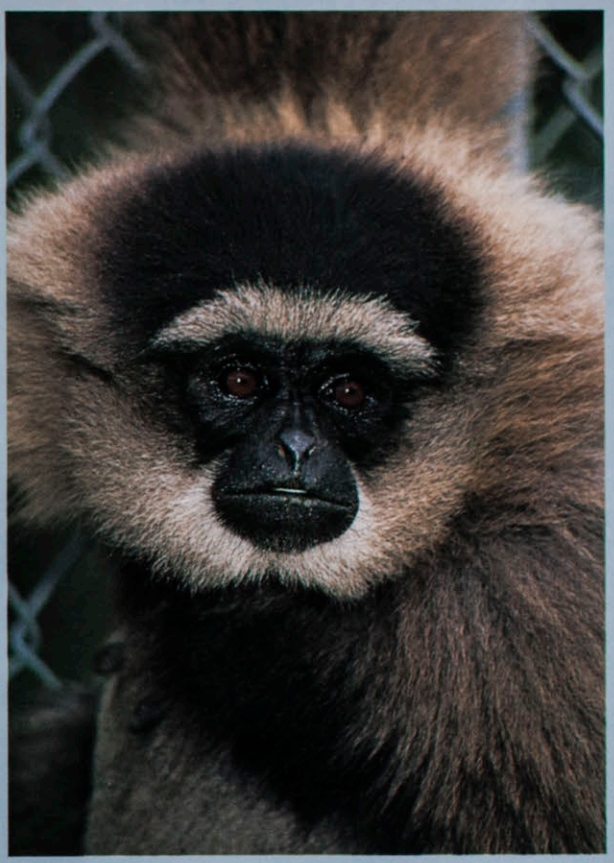
Saturday, May 16, 10 a.m., Museum of Natural History. Children ages 7 to 10

Learn about the lives of dinosaurs and other extinct reptiles in this hands-on class with Paleontologist Michael Berkoff. We'll examine some of the museum's fossil specimens, looking for clues as to how they lived, and learn the latest theories about their extinction as we tour the dinosaur hall. Then we will excavate fossils and make fossil casts just as real paleontologists do. $15 members, $20 nonmembers.

Lecture

■ THE GIBBONS OF SOUTHEAST ASIA

Sunday, May 31, 2 p.m., Jean Delacour Auditorium, Museum of Natural History. Adults and children 12 and older



The spectacular call of the gibbon can be heard for long distances and is the primary way that scientists—and poachers—locate wild populations: family units of these small arboreal apes of tropical and subtropical rainforests of southeast Asia occupy a territory and defend its boundaries by a vigorous vocal and visual display. Gibbons are brachiators (arm-swingers) and are incredibly agile in the tree tops, which is one reason they make popular zoo exhibits. But most countries now consider their wild gibbons to be endangered, threatened primarily by loss of their rainforest habitat but also by poaching and illegal trade in their body parts, which are used in the manufacture of traditional medicines.

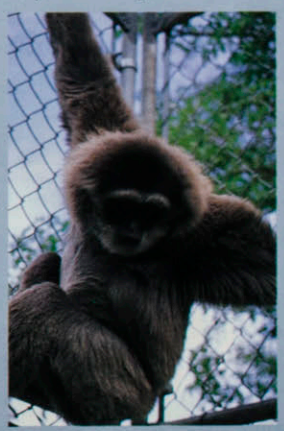
Alan Mootnick, Director at the International Center for Gibbon Studies, explains why gibbons have long fascinated people—scientists, in particular—and describes efforts to conserve these expressive and very beautiful primates. $7 members, $9 nonmembers, $5 students with ID.

■ THE GIBBON'S VOICE

Saturday, June 6, 10:30 a.m., International Center for Gibbon Studies, Santa Clarita. Children of all ages welcome with accompanying adult

On a special tour of the International Center for Gibbon Studies (ICGS), we will learn about these fascinating rainforest animals and why they are endangered. Our guide will be ICGS Director Alan Mootnick, who has been studying gibbons for 20 years and can give insight into the differences in behavior between wild and captive-bred primates.

The ICGS currently houses the second largest collection of gibbons in North America and has six of the eleven extant species. A highlight of our visit is the opportunity to view a brand new baby Moloch (the rarest of gibbon species) and its parents, the only Moloch pair to have successfully reproduced in captivity in the U.S. Please bring a picnic lunch if you wish to stay after the tour and enjoy lunch on the ICGS picnic grounds. $15 members, $20 nonmembers.



PHOTOGRAPHS COURTESY ALAN MOOTNICK

Behind-the-scenes tour

■ SOMETHING'S FISHY!

Saturday, June 13, 10 a.m., Museum of Natural History. Children ages 5 and up with accompanying adult

The Natural History Museum houses a vast collection of fishes, from tiny gobies carefully preserved in bottles to triggerfish and piranha skeletons and large shark jaws. Museum ichthyologist Jeff Seigel, a specialist in sharks, will show us the treasures of the collection and point out amazing and unusual features of these underwater creatures. After our tour of the collection "range," which is normally off-limits to museum visitors, we will dive into the Education classrooms for a fishy craft activity. $10 members, $15 nonmembers.

FAMILY FIELD TRIPS

■ COWBOY CAMPOUT AT HART RANCH

Overnight, Saturday, June 27 to Sunday, June 28, 6 p.m. to 8 a.m, Hart Park, Newhall. Children ages 5 and older with accompanying adult

Calling all cowboys and cowgirls! Be among the first to spend an exciting night at the William S. Hart Park. We will take a special hike around the ranch with naturalist Peter Rice and learn about some amazing night creatures. We will also meet the domestic animals that live at the ranch, get a special tour of the Hart Mansion, and make s'mores around the campfire while listening to wrangler legends. Participants must bring their own tent, sleeping bags, and air mattresses. $40 members, $50 nonmembers.

ANNOUNCEMENTS

Registration now open

■ ADVENTURES IN NATURE

July 13 to 17, July 20 to 24, July 27 to 31, and August 3 to 7, 10 a.m. to noon or 1 to 3 p.m., and August 10 to 14, 10 a.m. to noon. Museum of Natural History and Page Museum

Children from ages 3 to 13 learn about nature first hand in exciting participatory sessions with outstanding museum instructors. The week-long courses, which may be taken mornings or afternoons, offer opportunities to visit the curatorial laboratories, work with nature specimens, and make craft items to take home. While children are in class, adults may enjoy free museum programs. Children ages 14 and older are encouraged to apply for a limited number of Junior Volunteer positions, where they will help instructors in classes and aid in lunchtime games and supervision.

Classes run Monday through Friday, mornings (10 a.m. to noon) or afternoons (1 to 3 p.m.); the August 10 to 14 classes are held in the mornings only at the Page Museum. Children who are enrolled in both morning and afternoon classes will be supervised over the lunch break. Program costs are $80 per week-long class for members; $90 for nonmembers. Members receive additional discounts when enrolling two or more siblings. Children receive a special Adventures in Nature T-shirt with enrollment.

Moved to the Museum of Natural History!

■ THE TWELFTH ANNUAL INSECT FAIR

Saturday and Sunday, June 13 and 14, 10 a.m. to 5 p.m., Museum of Natural History

This year, the Insect Fair—the largest event of its kind in North America—will be held in the Museum of Natural History in Exposition Park. The fair features exhibits of living and preserved insects, demonstrations on how to make an insect collection, and displays about controlling household and garden pests. More than 60 exhibitors from all over the United States participate, and specimens, natural history books, and arts and crafts (all with an insect theme) are sold and exchanged.

For the weekend of the fair, the entire Museum of Natural History will be devoted to insects and their relatives, with attendance at the fair, displays, and guest speakers and educational programs included in the price of admission to the museum. We may even have Bug Burgers on our restaurant menu! For more information, contact the Insect Zoo (telephone: 213/763-3558; facsimile: 213/744-1042; e-mail: aevans@nhm.org).

PHOTOGRAPHS BY DICK MEIER

The Insect Fair, which is presented by the museum's Insect Zoo, is sponsored this year by Lincoln Mercury, which will display its newest vehicles during the event.

FAMILY FUNDAYS

*These family programs are **free** with museum admission for children ages 4 and older. No reservations are necessary, but space in some programs is limited, so please arrive early.*

ROCKIN' OUT

Saturday, May 16, 1:30 p.m., Discovery Center, Museum of Natural History

Celebrate California Archaeology Week with Museum Educator Nancy Fox. Learn about the prehistoric rock art of the Chumash Indians; then create rock art of your own to take home.

THE RISE OF ROYAL BREAD

Saturday, June 13, 1:30 p.m, Discovery Center, Museum of Natural History

Westlake Culinary School experts show us how to make bread rise, using "magic" microbes. You'll take home a sample of dough for baking your own mini-loaf.

CAR MAZE

Saturday, May 30, 2 p.m., Artopia, Petersen Automotive Museum

Create a challenging race track from ordinary objects like paper plates and popsicle sticks. You supply the creativity, we'll provide the rest.

CLEAN CARS!

Saturday, June 27, 2 p.m., Artopia, Petersen Automotive Museum

What can you make from two dishwashing liquid bottles? A car, of course. Bring two matching full-size, empty detergent bottles, and we'll show you how.

An Adventures in Nature brochure was sent to all members at the family level and above at the beginning of April. If you need additional information or are interested in sponsoring a child from an economically challenged family, please call 213/763-3534.

A DAY OF SUNSHINE

This summer, the Natural History Museum again brings more than 300 homeless children, ranging in ages from 6 to 14, to the Page Museum to enjoy a day of activities. The Day of Sunshine program, now in its seventh year, was established to provide these children with educational experiences beyond the realms of their daily lives in missions, shelters, and hotels. Their journey back to the Ice Age era of saber-toothed cats, dire wolves, and mammoths includes tours of the museum and adjacent asphalt pits, an exploration of the research laboratory and collections, and craft activities. At the end of their day, the children leave with full stomachs and the knowledge that they are always welcome at the museum.

Contributions to this program will be gratefully received by the museum's Education Division; for further information, please call Eileen Wallis at 213/857-6305.

PUBLIC PROGRAMS RESERVATION FORM

■ **By telephone:** Use your MasterCard or VISA. Call the Education Division at 213/763-3534, weekdays, 8 a.m. to 4 p.m. Credit cards are accepted only with a minimum charge of $20.

■ **By mail:** Complete the form below, fill in the charge information or enclose a check payable to Museum Foundation, and return your order form and payment with a self-addressed, stamped envelope. The form may be duplicated. Mail to: ***Education Division, Natural History Museum, 900 Exposition Boulevard, Los Angeles, CA 90007***

■ **Important: Reservation, Waiting List and Refund Policies.** Preregistration is required for all classes, workshops, and field trips and is recommended for all other Education Division programs. Tickets to auditorium events may be purchased at the door on a first-come, first-served basis; seating is not reserved. Reservations are not necessary for Family Fundays. Applicants for filled programs will be placed on a waiting list and contacted if vacancies or rescheduling occur. If you have paid for a filled program, your payment will be refunded in 4-6 weeks.

Cancellations must be made at least 6 business days prior to the first day of an event for the registrant to be eligible for a partial refund. No refunds can be given for cancellations made in the 5 days before the event.

Dates and times of programs are subject to change, and class sizes are limited. Please call 213/763-3534 weekdays between 8 a.m. and 4 p.m. to verify program dates, times, and availability.

■ **Special Assistance Available.** If you wish to attend a museum event and require auxiliary aids or services, please contact the museums' Americans with Disabilities Act (ADA) Compliance Officer at least three (3) business days prior to the event. The ADA Compliance Officer may be reached by telephoning 213/763-3417 (voice) or by calling that number via California Relay Service at 800/735-2929 (TTY).

( ) _____ HOME

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Mail to:
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Natural History Museum
900 Exposition Blvd.
Los Angeles, CA 90007

❑ My check is enclosed

❑ Charge my credit card:
- ❑ MasterCard
- ❑ VISA

Program	Number of participants	Price	Total Price

Total Remittance _____

Credit Card # _____ Expiration Date _____

Signature _____

Please list children's names, ages, and programs in which they are enrolling:

_____

_____

_____

continued from page 7

ever, and additional support is needed from corporations and individuals who share our goals."

If you or your company would like to support the museum's educational programs, please contact the Development Office at 213/763-3307 for information.

■ POSTAGE STAMP UNVEILED AT PETERSEN

In February, the Petersen Automotive Museum was the site for the Los Angeles unveiling of a new U.S. Postal Service stamp honoring the Model T Ford. A pictorial cancellation was designed specifically for the Petersen event, designating the museum as the official partner for the stamp's introduction into circulation. The new stamp is part of a series, "Celebrate the Century," recalling important events in U.S. history over the last 100 years.

MEMBERS & DONORS NEWS

■ SOMETHING DIFFERENT FOR DAD?

Give him year-long access to 300,000 square feet of automotive history and culture, with a gift membership in the Petersen Automotive Museum.

In addition to free admission to all four museums in the Natural History Museum family, Petersen members receive the *Petersen Quarterly,* an illustrated newsletter for car and history buffs, invitations to exclusive openings and events, and a 10 percent discount off purchases in all Natural History Museum stores. A membership in this exciting museum also provides opportunities for meeting people with similar interests and for enjoying quality time with children or grandchildren.

A Station Wagon membership ($50/year) admits two adults and four children up to age eighteen. An upgrade to the sporty Convertible level ($60/year) strengthens the ties to our museum complex with a subscription to *Terra* and invitations to members-only events at the Exposition Park museum.

Gift memberships in the Petersen Automotive Museum will be offered at a 20 percent discount between May 23 and June 21. Please call the Petersen Membership Services Office at 213/964-6359 for further information.

DINO SOUND STATION

The interactive adventure that RUMBLES and ROARS!

TOUCH ONE of the more than 60 "sound spots" on this 21- by 40-inch, extra-tough vinyl mat and begin an imaginative play adventure that sends you back through time. Included are a chart that identifies and gives information about all dinosaurs pictured on the mat as well as four authentic 6-inch dinosaur models—*Stegosaurus*, *Apatosaurus*, *Edmontosaurus*, and *Tyrannosaurus rex*.

PRICE $35.00

AVAILABLE in the Gallery Store; for more information or mail order inquiries, call 213/763-3420.

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The Natural History Museum exists to advance knowledge and to enable people of all ages, backgrounds, and interests to understand and appreciate their natural and cultural heritage. The museum assembles, conserves, interprets, and holds in trust collections of irreplaceable objects from nature and human history. These collections reveal the history of the Earth and the evolution and diversity of life and culture. They sustain programs of research, exhibits, education, and publication.

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World Wide Web: http://www.nhm.org

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General information 213/763-DINO

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■ William S. Hart Museum
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A spectacular journey by rail!
October 3 to 10, 1998

If you love dramatic places, our Copper Canyon tour is designed for you! This is an exclusive program that combines first-class travel arrangements and accommodations with incredible scenery and cultural experiences.

You will travel in a deluxe parlor car on the Chihuahua al Pacific Railway—the "Train Ride in the Sky," traversing from sea level to 7,000 feet in the foothills of the majestic Sierra Madre Mountains. Accommodations are in quaint, historic inns and the finest hotels in the region.

Here is your chance to savor Mexican culture, architecture, and scenic majesty. The tour price of $1,900 is all-inclusive, except for airfare from Los Angeles.

For further information on this and other exciting custom-designed museum-sponsored trips—to destinations such as northern Spain, the Florida Everglades, and the Cro-Magnon Caves of France—please call Christine Robison, Travel Program Coordinator, at 213/763-3350, or visit our web site at www.nhm.org/travel.